Title of the invention

Data capturing and processing system for a roller bearing and roller bearing with such a system

Description

Field of the invention

The invention relates to a data capturing and processing system for a roller bearing according to the preamble of patent claim 1 and to a roller bearing with such a system.

Background of the invention

DE 101 36 438 A1 discloses a sensor arrangement in a roller bearing which is suitable for determining physical variables during the movement of a component mounted in the roller bearing. In the case of the sensor arrangement, the forces and moments acting on the bearing shells of the roller bearing are captured by sensor elements and electronic devices that are attached to the bearing shells being used to detect mechanical stresses or other physical reactions of the bearing shells to these forces and moments. The sensor elements are in this case formed as resistive strain gages, which are preferably fastened in a groove at the periphery of

the fixed bearing shell, it being possible for the latter to be both the inner bearing shell or the outer bearing shell of a roller bearing.

According to this publication, the resistive strain gages may be applied over an insulating layer on a metal intermediate carrier, such as for example a small plate. A further carrier material, formed as a leadframe, surrounds said intermediate carrier with the resistive strain gages and serves for receiving electronic devices and strip conductors. To fasten the intermediate carrier and the leadframe to the bearing shell, they are pressed or welded into the groove of the same.

In addition, it is known from this DE 101 36 438 A1 that the resistive strain gages can be applied to the metal intermediate carrier in the form of an axially and tangentially measuring full-bridge or half-bridge connection. Moreover, this publication discloses that, with the electronic devices, a signal evaluation and signal transmission to further measuring points or other evaluation circuits or to a connection plug takes place. The signal transmission in the case of this known measuring bearing may take place serially via a digital or analog bus system, which is arranged for example in a motor vehicle.

Although this known measuring bearing has a comparatively high and advantageous degree of integration on account of the arrangement of sensor elements and electronic devices in the groove of the bearing ring, a relatively wide groove is required for its construction. Since, however, the groove in such a bearing ring is to be kept as small as possible to avoid weakening of the component, conversion of the arrangement known from DE 101 36 438 A1 into a marketable product is not very likely. The technical problem described occurs in particular in the case of roller bearings that are axially very narrow.

Furthermore, the applicant's DE 103 04 592 A1, which is not a prior publication, discloses a measuring bearing in which the strain gages, the electrical conductors and/or the electronic devices are sputtered directly onto the surface of the recess of the bearing ring or onto the silicon dioxide layer.

Although the construction of the measuring bearing according to the last-mentioned, not previously published DE 103 04 592 A1 is accompanied by distinct advantages over the prior art cited at the beginning with regard to the compactness of a measurement data capturing and processing system formed on a roller bearing, there is a demand for a variant which can be produced at still lower cost. For

example, the preparation of the surface for fastening the system to a bearing ring is complex and expensive, since it has to be precise and clean.

Summary of the invention

Against this background, the object for the invention is to present a measurement data capturing and processing system for a roller bearing and an associated measuring roller bearing which has a compact construction and can be produced at low cost. The preparation and fastening of the sensor arrangement on the bearing are to be simplified in particular.

The solution achieving this object is obtained from the features of the main claim and from the features of the dependent claims.

Accordingly, the invention relates to a measurement data capturing and processing system for a roller bearing in which at least one sensor element, strip conductors and electronic components are arranged adjacent a flexible carrier material.

Sensor elements are, for example, the known strain gages with conductors, for example of nickel-chromium, and other resistance elements or strip conductors of copper that are specially produced and known per se, which according to one

refinement of the invention are interconnected in the manner of a resistance bridge. Such resistance bridges may be applied to flexible carrier objects in strip form or else directly to the flexible carrier material.

A further refinement of the invention provides one or more capacitors as sensor elements. The basic construction of the sensors is similar to the construction of a plate capacitor. Conductor areas or metal foils applied to the carrier material over large surface areas as "capacitor plates" are separated from one another by the flexible carrier material as a dielectric. An alternative here is also that a number of areas/foils or capacitors are connected in series.

The conductor areas on one side of the carrier material can be at least partially elastically deformed by the influences to be captured from the roller bearing in the direction of the opposite areas/foils to the extent that the distance between the areas/foils opposite one another, and with it the capacitance of the capacitor/capacitors, changes. The influences from the roller bearing are, for example, elastic deformations of a bearing ring from the rolling contact of the rolling bodies with the bearing ring. The elastic deformations of the ring are transferred to the elastic areas of the capacitor, so that the change in the

capacitance is an assessment criterion for the elastic deformation in the bearing ring.

Alternatively, the elastically deforming surface of the roller bearing component forms one plate of the capacitor, which is then connected on one side of the carrier material to the carrier material, for example by means of a very thin and elastic layer of adhesive. On the other side of the correspondingly thin and elastic carrier material, one or more of the plates of the capacitor is or are then arranged in the form of the conductor areas or foils. Plated-through holes through the carrier material are not required in the case where capacitors are used as sensor elements.

The sensor elements, the strip conductors and the electronic components are directly connected to the flexible carrier material on the side facing away from the roller bearing component - that is on top, but preferably underneath. This is not already known from DE 103 04 592 A1, since in the case of the latter the strain gages are applied to an insulating substrate which is applied directly to a roller bearing component.

In comparison with this prior art, the invention offers a series of advantages. For instance, the described construction allows the measurement data capturing and processing system together with all the sensor elements to be

produced as a complete unit in a protected environment and subsequently connected to the respective roller bearing. As a result, already before connection to the roller bearing, there is the possibility of testing the functional capability of the measurement data capturing and processing system, making changes to it or not using it any further as it is what is known as a reject. Furthermore, since the sensor elements are not directly applied to the surface of the roller bearing component, no costly preparations of the surface are required.

A further advantage is that, with a releasable connection between a roller bearing component and the measurement data capturing and processing system, in the event of a defect said system can easily be removed and replaced by one which is operational, without complex work on the roller bearing being necessary. This is of commercial significance in particular in the case of large roller bearings. This replacement system may, for example, also be one with which different measurements can be carried out.

It should be mentioned as a further advantage that the application of sensor elements, strip conductors and electronic components to a carrier material lying flat on an underlying surface is much less costly than production steps of this type on curved surfaces, so that, along with improved

functionality in comparison with the prior art, production costs can be saved.

According to a preferred embodiment of the invention, it is provided that the sensor elements are fastened on the underside, and the strip conductors and the electronic components are fastened on the upper side of the flexible carrier material. As an alternative to this, it is provided that the electronic components and the strip conductors are arranged on the underside and the sensor elements are arranged on the upper side of the carrier material.

To pass on the deformation-induced changes in resistance determined by the sensor elements, they are connected by signaling technology via contacting elements, either by means through-hole plating elements to the strip conductors arranged on the opposite side of the flexible carrier material, or to adjacent electronic devices by means of conductor areas/paths. The through-hole plating elements are preferably formed in the flexible carrier material and aligned perpendicularly in relation to the longitudinal and transverse extents of said carrier material.

The sensor elements are preferably fastened on that side of the flexible carrier material which is facing the surface of that roller bearing component on which the data capturing and processing system is arranged.

A further aspect of the invention relates to the formation of the flexible carrier material, which preferably comprises a film or a number of films lying one on top of the other. This film or these films may in this case consist of a plastic or a thin and flexible metal foil. As an alternative to this, the film may be produced from modern materials, such as ceramic. If a plastic is used, a polyimide is preferred.

The application of the sensor elements, the strip conductors and the electronic components to the flexible carrier material preferably takes place by means of a screen printing process, by vapor deposition or by depositing conducting, semiconducting and/or insulating materials. The special case of adhesively attaching separately produced sensor elements onto the flexible carrier material has already been mentioned of course.

In addition, it is also possible for the sensor elements, the strip conductors and/or the electronic components to be respectively formed on a separate flexible carrier material, which are connected to one another to form a common flexible carrier material.

With respect to the definition of the electronic components, it should not go unmentioned that they can be formed as discrete components such as resistors, capacitors

and the like. In addition, these electronic components can also be formed as microprocessors or as complete microcomputers. It is important, however, that initially an input stage from at least one amplifier is connected to the sensor elements.

If the flexible carrier material is formed such that it is largely thin and flexible, it may be provided according to another development of the invention that the flexible carrier material has a greater mechanical rigidity in the region of the amplifier, a microprocessor or microcomputer than in adjacent regions. This may be realized for example by thicker carrier material at this point, or a reinforcement of the carrier material by material being applied or the like.

If the sensor elements are adhesively attached on the flexible carrier material, it may be provided according to another form of the invention that an adhesive is applied to the flexible carrier material for fastening the sensor elements and is covered with a protective film before the sensor elements are attached. This procedure is meaningful for example whenever the measurement data capturing and processing system is to be formed in such a variable manner that, depending on the application, differently formed sensor elements are to be used for measuring operations.

Moreover, it is meaningful to cover the surface of the sensor elements and of the strip conductors with an electrically insulating layer. This insulating layer may consist of a solder resist or is formed by the adhesive with which the system is fastened to the roller bearing component.

A further refinement of the invention provides that the electrical and electronic components as well as the insulating layers and the flexible carrier material, but also ~~the sensor elements, at least partially consist of or are constructed from conducting, semiconducting and/or insulating~~ polymers.

The measurement data capturing and processing system according to the invention is used with advantage on a roller bearing, the measurement data capturing and processing system being fastened in a recess or in a peripheral groove, or on a groove-less or recess-less annular area, on one of two roller bearing components which enclose rolling bodies between them. As is known, the inner ring and outer ring of a roller bearing are bearing components of this type. The measurement data capturing and processing system according to the invention is advantageously also used on linear bearings.

If the data capturing and processing system is fastened in a recess or groove on a roller bearing component, it is recommended to cover it with an encapsulating material if

permanent, unchanged use of such a measuring roller bearing is meaningful and desired.

Finally, it should be mentioned that the measurement data capturing and processing system is fastened with advantage on the outer side of a housing flange on the inner wall of which rolling bodies roll.

Brief description of the drawings

The invention can be explained in more detail on the basis of exemplary embodiments. In the drawing:

Figure 1 shows a schematic cross section through the measurement data capturing and processing system formed according to the invention, with a strain gauge,

Figure 2 shows a schematic cross section through a roller bearing outer ring and with a measurement data capturing and processing system fitted in a peripheral groove, with resistance bridges of copper, and

Figure 3 shows a schematic cross section through a measurement data capturing and processing system formed according to the invention, with a capacitor.

Detailed description of the drawings

The representation in Figure 1 shows a schematic cross section through a data capturing and processing system 1 formed according to the invention, the central component of which is a flexible carrier material 2, formed as a film. Located on the underside of this carrier material 2 are strain gages 3, which are arranged as sensor elements 19 and ~~in this case are aligned into the plane of the representation, but are alternatively also aligned in any~~ desired directions, and in this specific exemplary embodiment are applied photolithographically but are alternatively also applied by means of screen printing. The underside of the flexible carrier material 2 is defined as that side which, with respect to fastening, faces in the direction of the roller bearing component on which the data capturing and processing system is arranged. In this case, the data capturing and processing system(s) is/are arranged for example on an inner periphery or outer periphery or on an end face of one or more inner or outer bearing rings or the like.

Moreover, it can clearly be seen in Figure 1 that the free surfaces of the strain gages 3 are covered with an insulating material 8, which in this example consists of a solder resist or adhesive.

Arranged on the opposite upper side of the carrier material 2 are strip conductors 4, individual electronic components 5 and a microcomputer 6, it being possible for the individual electronic components 5 to be, for example, electrical resistors, capacitors and the like. These strip conductors 4, electronic components 5 and microcomputers 6 are applied to the carrier material 2 by one or various production technologies, the vapor deposition and/or application of conducting and semiconducting and/or insulating materials preferably being performed photolithographically but also alternatively by means of screen printing.

It is expressly not excluded in this connection that the electrical and electronic components as well as the insulating layers and the flexible carrier material consist of or are constructed from polymers.

As Figure 1 also shows, the strip conductors 4 on the upper side of the flexible carrier material 2 are likewise covered with an insulating material 8. Moreover, formed at various points on the flexible carrier material 2 are electrical contact pads 7, which serve as connecting or soldering terminals for establishing an electrical connection between the electronic components 5 or the terminals of the microcomputer 6 and the strip conductors 4.

For the electrical connection of the strain gages 8 and at least some of the strip conductors 4 on the opposite side of the flexible carrier material 2, so-called through-hole plating elements 13 are arranged at suitable points in the same, extending substantially perpendicularly in relation to the longitudinal and transverse extents of the flexible carrier material 2. Through-hole plating elements of this type are, for example, electrical conductors of copper, with which plated-through contact is established for the connection.

A measurement data capturing and processing system 1 constructed in such a way can be fastened to a roller bearing comparatively simply. Figure 2 shows in this respect, in an exemplary embodiment of the invention, that such a measurement data capturing and processing system 1 is fitted in a peripheral groove 12 of a roller bearing outer ring 9 and fastened on an adhesive layer 10 applied to the bottom of the groove. However, this adhesive 10 may also be applied similarly well on the underside of the flexible carrier material 2, covering the strain gages, before assembly begins.

As an alternative to the representation that is shown in Figure 1, the sensor element 19 is formed by resistance bridges 14 with conductors of copper instead of the strain

gages 3. The data capturing and processing system 1 on the flexible carrier material 2 is in this case arranged on the outer periphery of the bearing outer ring 9 in such a way that the resistance bridges 14 face in the direction of the rolling bodies (not represented here) of the roller bearing.

Finally, Figure 2 shows that, in this exemplary embodiment, the measurement data capturing and processing system 1 is covered with an encapsulating compound 11, ~~providing protection from mechanical and electrical influences.~~

Figure 3 shows a data capturing and processing system 15, the sensor element 19 of which is formed by a plate capacitor 16. Arranged for this purpose on the upper side of the carrier material 2 are two capacitor plates connected in series in the form of conductor areas 17, which are formed such that they are relatively rigid. On the underside of the carrier material 2 facing toward the bearing (not represented), a further plate-like conductor area 18 is fixed. In the same way as the carrier material 2, the conductor area 18 is formed from polyimide in the manner of a film and elastically, so that deformations from the bearing ring are transmitted through the conductor area 18 to the carrier material and, by means of the consequently changed distance between the conductor areas 17 and the conductor

area 18, the capacitance of the plate capacitor 16 can be influenced as a measured value. An amplifier 20 is connected to the plate capacitor 16.

List of designations

1	Data capturing and processing system
2	Carrier material
3	Strain gage
4	Strip conductor
5	Electronic component
6	Microcomputer
7	Contact pad with respect to the strip conductor
8	Insulating layer
9	Bearing outer ring
10	Adhesive material
11	Encapsulating material
12	Groove in the bearing outer ring
13	Contacting element
14	Resistance bridge
15	Data capturing and processing system
16	Plate capacitor
17	Conductor area
18	Conductor area
19	Sensor element
20	Amplifier